CLAIMS

We claim:

1. A variable optical attenuator comprising:

an input fiber for receiving an input optical signal to be attenuated;

an output fiber for outputting said attenuated optical signal;

at least one phase changing element, disposed in the optical path between said input fiber and said output fiber; and

a drive source operative to change the phase of light passing through at least part of said at least one element;

wherein the operation of said phase changing element is effected by rotation of an optical axis of said element.

2. A variable optical attenuator according to claim 1 and wherein said input optical signal has an effectively fundamental mode structure and said output fiber is a single mode fiber, and said change in the phase of light passing through said at least part of said at least one element is operative to change the mode structure of at least part of said input optical signal to a higher order mode, such that said part of said input optical signal cannot propagate freely in said output fiber.

3. A variable optical attenuator according to claim 1, and wherein said at least one phase changing element is at least one liquid crystal element.

4. A variable optical attenuator according to claim 2, and wherein said at least one phase changing element is at least one liquid crystal element.

5. A variable optical attenuator according to claim 3, and wherein said at least

one liquid crystal element comprises a serial pair of parallel aligned liquid crystals, orthogonally aligned such that said attenuator is insensitive to the direction of polarization of said optical signal.

6. A variable optical attenuator according to claim 3, and wherein said at least one liquid crystal element comprises a serial pair of twist geometry liquid crystals, having the same overall twist angle but with the twist directions reversed, and disposed such that at the transition between said crystals, the mutual alignment of the twist structure is 90° such that said attenuator is insensitive to the direction of polarization of said optical signal.

7. A variable optical attenuator according to claim 3, and wherein said at least one liquid crystal element comprises a liquid crystal divided into at least two orthogonally aligned pixels, such that said attenuator is insensitive to the direction of polarization of said optical signal.

8. A variable optical attenuator according to claim 1, and wherein said phase changing element is selected from a group consisting of an electro-optic element, a thermo-optical element and a magneto-optical element.

9. A variable optical attenuator according to claim 1, and wherein said part of said phase changing element is defined by at least one pixel on said element.

10. A variable optical attenuator according to claim 3, and wherein said part of said phase changing element is defined by at least one pixel on said element.

11. A variable optical attenuator according to claim 9, and wherein said at least one pixel is two pixels, arranged in opposite halves of said element.

12. A variable optical attenuator according to claim 9, and wherein said at least one pixel is four pixels arranged in opposite quarters of said element, and said drive source is operative to change the phase of light passing through two diagonally opposite ones of said pixels

13. A variable optical attenuator according to claim 9, and wherein said at least one pixel is an array of a number of strip pixels running across the element, said array dividing said element into approximately equal pixelated and non-pixelated areas.

14. A variable optical attenuator according to claim 1, and wherein said input fiber and said output fiber are disposed such that light passes by transmission between them.

15. A variable optical attenuator according to claim 1, and also comprising a reflecting surface, and wherein said input fiber and said output fiber are disposed such that light passes by reflection between them.

16. A variable optical attenuator according to claim 15, and wherein said reflecting surface is formed on the rear side of said phase changing element.

17. A variable optical attenuator according to claim 9, and wherein said at least one pixel is formed by means of at least one pixelated electrode located essentially over the area of said at least one pixel.

18. A variable optical attenuator according to claim 9, and wherein said at least one pixel is formed by means of at least one electrode located remotely from the area

of said at least one pixel.

19. A variable optical attenuator according to claim 3, and wherein said at least one liquid crystal element comprises a serial pair of parallel aligned liquid crystals with a half wave plate disposed between them, such that said attenuator is insensitive to the direction of polarization of said optical signal.

20. A variable optical attenuator according to claim 19, and wherein said half wave plate is operative as a substrate for one of said liquid crystal elements.

21. A variable optical attenuator according to claim 19, and wherein said half wave plate is operative as an alignment layer for one of said liquid crystal elements.

22. A variable optical attenuator according to claim 3, and wherein said at least one liquid crystal element comprises a liquid crystal with a quarter wave plate disposed in proximity to said liquid crystal, and also comprising a reflecting surface, and wherein said input fiber and said output fiber are disposed such that light passes by reflection between them.

23. A variable optical attenuator according to claim 22, and wherein said reflecting surface is formed on the rear side of said quarter wave plate.

24. A variable optical attenuator according to claim 22, and wherein said quarter wave plate is operative as a substrate for said liquid crystal element.

25. A variable optical attenuator according to claim 22, and wherein said quarter wave plate is operative as an alignment layer for said liquid crystal element.

26. An optical device comprising an input fiber, an output fiber and at least one phase changing element operative to change the phase of part of the cross section of light passing from said input fiber to said output fiber, wherein said device is operative as a mode-converter.

27. An optical attenuator comprising an input fiber, an output fiber and at least one phase changing element operative to change the phase of part of the cross section of light passing from said input fiber to said output fiber, wherein said light passes from said input fiber to said output fiber by transmission.

28. An optical attenuator according to claim 27, and wherein said change in the phase of part of the cross section of light passing from said input fiber to said output fiber is such that the mode structure of said light is changed such that said light cannot propagate freely in said output fiber.

29. An optical attenuator according to claim 28, and wherein said input fiber is a single mode fiber, and said output fiber is a single mode fiber, and wherein said mode structure of at least part of said light is changed to a higher order mode, such that said part of said light cannot propagate freely in said output fiber.

30. An optical attenuator according to claim 27, and wherein said at least one phase changing element is at least one liquid crystal element.

31. An optical attenuator according to claim 30, and wherein said at least one liquid crystal element comprises a serial pair of parallel aligned liquid crystals, orthogonally aligned such that said attenuator is insensitive to the direction of polarization of said light.

32. An optical attenuator according to claim 30, and wherein said at least one liquid crystal element comprises a serial pair of twist geometry liquid crystals, having the same overall twist angle but with the twist directions reversed, and disposed such that at the transition between said crystals, the mutual alignment of the twist structure is 90°, such that said attenuator is insensitive to the direction of polarization of said light.

33. An optical attenuator according to claim 30, and wherein said at least one liquid crystal element comprises a liquid crystal divided into at least two orthogonally aligned pixels, such that said attenuator is insensitive to the direction of polarization of said light.

34. An optical attenuator according to claim 27, and wherein said at least one phase changing element is pixelated.

35. An optical attenuator according to claim 27, and wherein said change in the phase of part of the cross section of light is effected by means of electrodes associated with said at least one phase changing element.

36. An optical attenuator according to claim 35, and wherein said attenuator is a variable attenuator.

37. A variable optical attenuator according to claim 30, and wherein said at least one liquid crystal element comprises a serial pair of parallel aligned liquid crystals, with a half wave plate disposed between them, such that said attenuator is insensitive to the direction of polarization of said optical signal.

38. A variable optical attenuator according to claim 37, and wherein said half

wave plate is operative as a substrate for one of said liquid crystal elements.

39. An integrated phase changing element for use in a variable optical attenuator, comprising a pixelated phase changing element, at least one detector element, and drive circuitry for controlling the phase change introduced in the passage of light through at least one of the pixels of said pixelated phase changing element.

40. A multi-channel variable optical attenuator comprising:

a plurality of input fibers for receiving a plurality of input optical signals to be attenuated;

a plurality of output fibers for outputting said plurality of optical signals after being attenuated, individual ones of said output fibers being aligned generally opposite individual ones of said input fibers;

at least one phase changing element, disposed in the optical path between one of said input fibers and one of said output fibers; and

a drive source operative to change the phase of light passing through at least part of said at least one element;

wherein the operation of said phase changing element is effected by rotation of an optical axis of said element.

41. A multi-channel variable optical attenuator according to claim 40, and wherein said at least one phase changing element is part of a pixelated single element comprising a plurality of phase changing elements.

42. A multi-channel variable optical attenuator comprising:

a plurality of input fibers;

a plurality of output fibers, individual ones of said output fibers being aligned generally opposite individual ones of said input fibers; and

at least one phase changing element operative to change the phase of part of the cross section of light passing from at least one of said plurality of input fibers to at least one of said plurality of output fibers, wherein said light passes from said input fiber to said output fiber by transmission.

43. A multi-channel variable optical attenuator according to claim 42, and wherein said at least one phase changing element is part of a pixelated single element comprising a plurality of phase changing elements.